Vol. XXIII, pp 61-64 April 19, 1910

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

THE SCALES OF THE CLUPEID FISHES.

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The scales of an ordinary Clupeid are very thin, more or less circular, and very finely sculptured. In *Alosa sapidissima* they vary from longitudinally to transversely oval on different parts of the same fish, while the larger and best developed scales (about 16 mm. each way) are subquadrate. A closer examination of the scales of *A. sapidissima* shows the following features: Apical field sharply separated from the rest, much broader than long, without circuli, but with very numerous (2½–3 in a mm.) delicate radii or grooves, which scallop the apical margin, and have between them on that margin a series of low lobes or angles, making the scale obscurely ctenoid; these lobules or denticulations can also be seen more or less clearly repeated once or twice in the submarginal area, marking periods of cessation of growth, and indicating the process whereby the rows of spines in the apical field of a *Beryx* scale are formed. Delicate lines of growth can be seen also in the other parts of the scale, but they have nothing to do with the circuli, which exist as exceedingly fine lines (about six in 170 μ) all over the scale except in the apical field. These circuli are transverse in the middle and reach the lateral margins very obliquely. The basal region of the scale is inclined to be thrown into three radiating folds, suggesting a slight approach to the basal radii of the Percoids, etc., but these folds are not marked by any signs of radii.

The most striking feature of the scale remains to be mentioned. Everywhere except in the apical field, at variable intervals averaging perhaps half a mm., there are grooved lines crossing the scale, approximately following the circuli, bent on the elevations between the basal grooves or folds, and curving

upwards to reach the margin at an acute angle. At first sight the nature of these structures seems wholly obscure, but in a longitudinally oval scale, probably from the caudal peduncle, it is seen that they pass gradually into apical radii. The first stage of modification is that in which the apical radii on each side of the middle become elbowed or curved at the base, forming a sort of J. In *Catostomus* the *basal* radii show this condition, and the tendency is for the curved part of the J to disappear, leaving radii which no longer point to the nuclear area. In *Alosa* this curving of the apical radii continues until a U rather than a J is formed, one arm of the U now pointing apicad to the nuclear area. Then the inner arm loses all connection with the nucleus, and those of opposite sides meet at an acute angle, forming a sort of reversed V. From this it is a comparatively short step to a single line running transversely across the scale. All this is complicated, especially in some scales, by various degrees of anastomosis, and the frequent disappearance of the inner part of the line. Nevertheless, by taking different scales from a single example of the *Alosa*, it is possible to demonstrate every transition from apical radii to transverse lines *below* the nuclear area; the conclusion being that these lines, which I have found only in Clupeidæ, are really greatly modified apical radii. Dr. Evermann kindly sent me some scales of very young *Alosa sapidissima* from the fish ponds at Washington, D. C. These scales, only about 2 mm. diameter, do not look like those of the adult, but they correspond exactly with the nuclear region of the latter. They show a strongly differentiated sculptureless apical field; the rest of the scale is covered by very fine wholly *transverse* circuli, and exhibits two or three of the lines representing modified radii, which are transverse, more or less bent apicad and obtusely angled in the middle. Thus the young scale does not throw any light on its evolution, and is, taken by itself, much more difficult to interpret than that of the adult. I am indebted to Dr. B. W. Evermann and Dr. S. Graeniche for other Clupeid scales, which all possess the same essential features as those of *Alosa*. They may be described as follows:

(1.) *Clupea harengus* L. Sandy Island. Scales about 8 mm. long and $7\frac{1}{3}$ broad; structure as in *Alosa*, the apical radii feeble, the trans-

verse circuli reaching the margin at a larger angle, the transverse radii (if they may be so called) essentially as in *Alosa*. There is no generic difference from *Alosa* in squamation.

(2.) *Sardinella humeralis* C. & V. Tampa, Fla. (Milwaukee Museum). Scales about 4 mm. broad and 3 long, with evident laterobasal angles. Scale formed and sculptured as in young *Alosa*, except for its much greater breadth, and some crenulation of the very thin apical margin, with rudimentary radii. There are three transverse radii, but the third presents only its middle part, running into the margin where it is concave. The circuli are strictly transverse, most reaching the margin practically at a right angle. If these scales are not immature, they at any rate represent a stage corresponding with immature *Alosa*, but not in any sense primitive.

(3.) *Pomolobus pseudoharengus* (Wilson) and *P. æstivalis* (Mitch.) both from six miles off Liverpool, N. S. Large yellowish scales, 10 or 11 mm. broad, but those of *P. pseudoharengus* more transverse, evidently broader than long, those of *P. æstivalis* about as broad as long. The markings are quite the same, and of the *Alosa* pattern; corresponding, however, to a rather immature stage of *Alosa*.

(4.) *Pomolobus pseudoharengus* (Wilson). Lake Ontario, Monroe Co., N. Y. Colorless scales little more than 4 mm. broad, evidently immature. I do not know any way to distinguish them from young scales of *Alosa*.

Thus the Clupeid scales so far examined are exceedingly uniform, and exceedingly distinct from all others I have seen. I have also examined *Knightia eocæna* Jordan, from the Eocene of Green River, Wyoming. In this the scales are large and very broad, and show the characteristic transverse circuli very well. I can not make out any radii, transverse or otherwise, but the thin edges of the scale are not preserved. *Meletta sardinites* Heckel, a fossil species from Radoboj, is figured as having the scales with three or four very strong apical radii, and the same basal. This can not be a *Meletta* (i. e. *Pomolobus*) or a *Clupea;* it has no resemblance to any Clupeid known to me.